
Feasibility of Using Kalina Cycles in Modular Solar Trough Systems

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Introduction

Design Constraints:

Hot Resource Case

Hot oil available at 735°F; minimum return temperature 555°F

93 MW heat available over temperature range

Low Resource Case

Hot oil available at 580°F; minimum return temperature 460°F

54 MW heat available over temperature range

Air cooling with 80°F ambient air or water cooling with 78°F from cooling tower

Limits of Analysis

Examined only existing Kalina Cycle designs — no original designs

Developed heat balances for performance estimates only — no cost estimates available



Description of Kalina Cycle System 33

Kalina Cycle System 33 has following features:

Parallel steam and ammonia-water cycles

Use of “back-pressure” turbines to avoid vacuum and air intrusion into system

Steam cycle has extraction to provide two levels of recuperative heating

Regenerative heating and evaporation of ammonia-water working fluid using turbine exhaust

Two-component working fluid mixture allows lower condensation temperature and lower coolant flow rates.

Boiler designs are once-through, with no drums, drum platforms, or level controls

Working fluid composition allows use of conventional materials

Simplified 4 MW KCS33 demonstration plant has met full-load performance estimates

Performance Summary

	Cold Resource Case		Hot Resource Case	
	Air-Cooled	Water-Cooled	Air-Cooled	Water-Cooled
Heat Available (MW)	54.27	54.27	93.16	93.16
Heat Rejected (MW)	37.35	36.87	61.25	60.77
Heat Recuperated (MW)	117.36	111.69	192.42	181.53
Gross Electrical Output (MW)	16.48	16.93	31.14	31.58
First Law Efficiency (gross electrical)	30.36%	31.20%	33.43%	33.90%
Carnot Cycle Maximum	48.09%	48.28%	54.83%	54.99%
Second Law Maximum	42.69%	43.25%	49.05%	49.54%
Second Law Efficiency	71.12%	72.13%	68.15%	68.43%



Equipment Selection

Heat Exchange Equipment

- HRSG/HRVG: Conventional once-through vapor generator
- Evaporators: Shell & tube or “hybrid”
- Recuperators: Vertical shell & tube or “hybrid”
- Condenser (water): Vertical shell & tube, plate, or hybrid
- Condenser (air): Horizontal multi-pass finned-tube (technology developed by Hudson)

Pumps

- Booster Pumps: Vertical can
- Main Feed Pumps: Horizontal split

Turbines

- Steam Turbine: Backpressure axial turbine with extraction
- Vapor Turbine: Backpressure axial turbine or radial expander



Material Selection

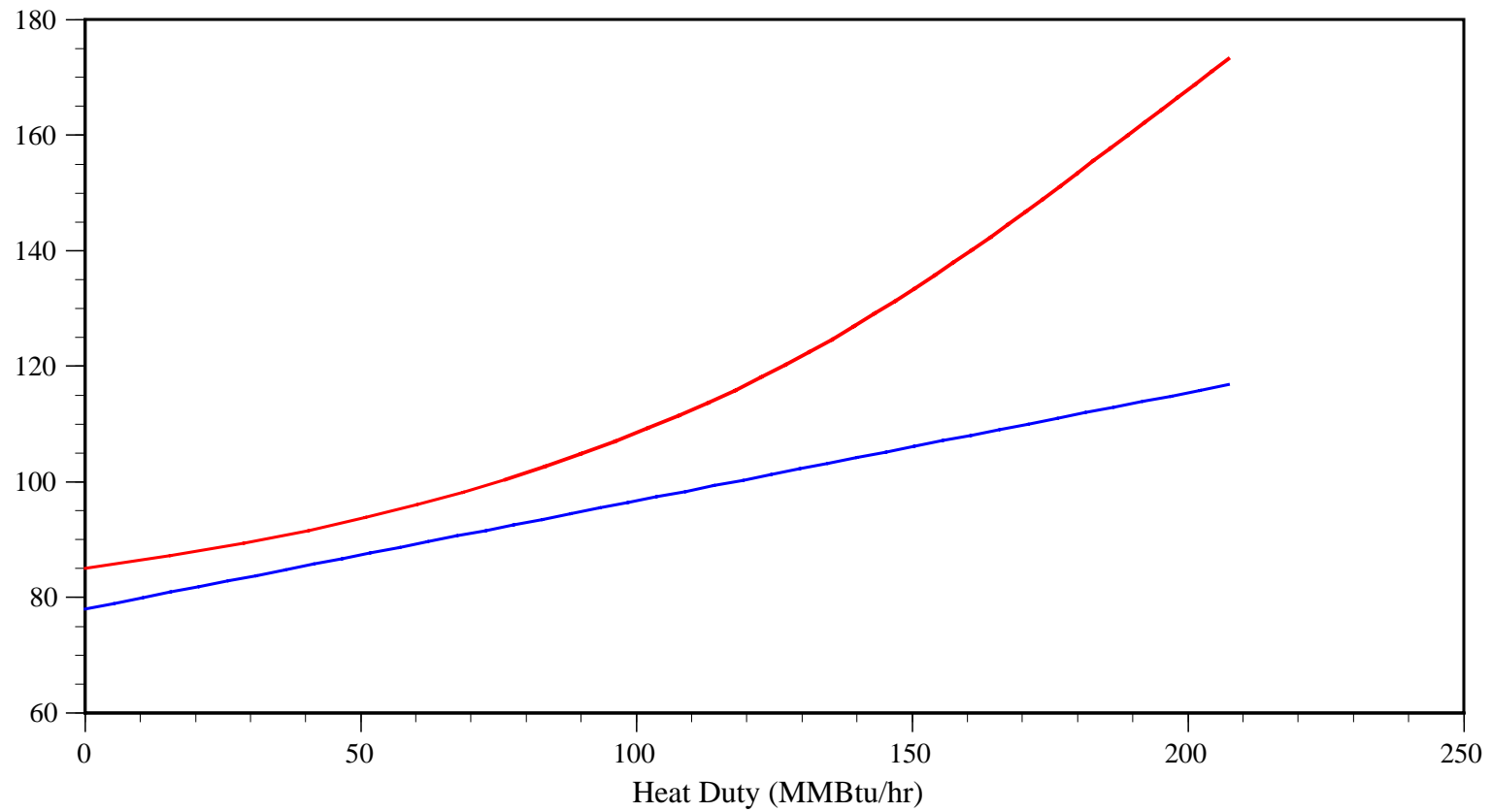
Virtually all components can be made of carbon steel

Exceptions:

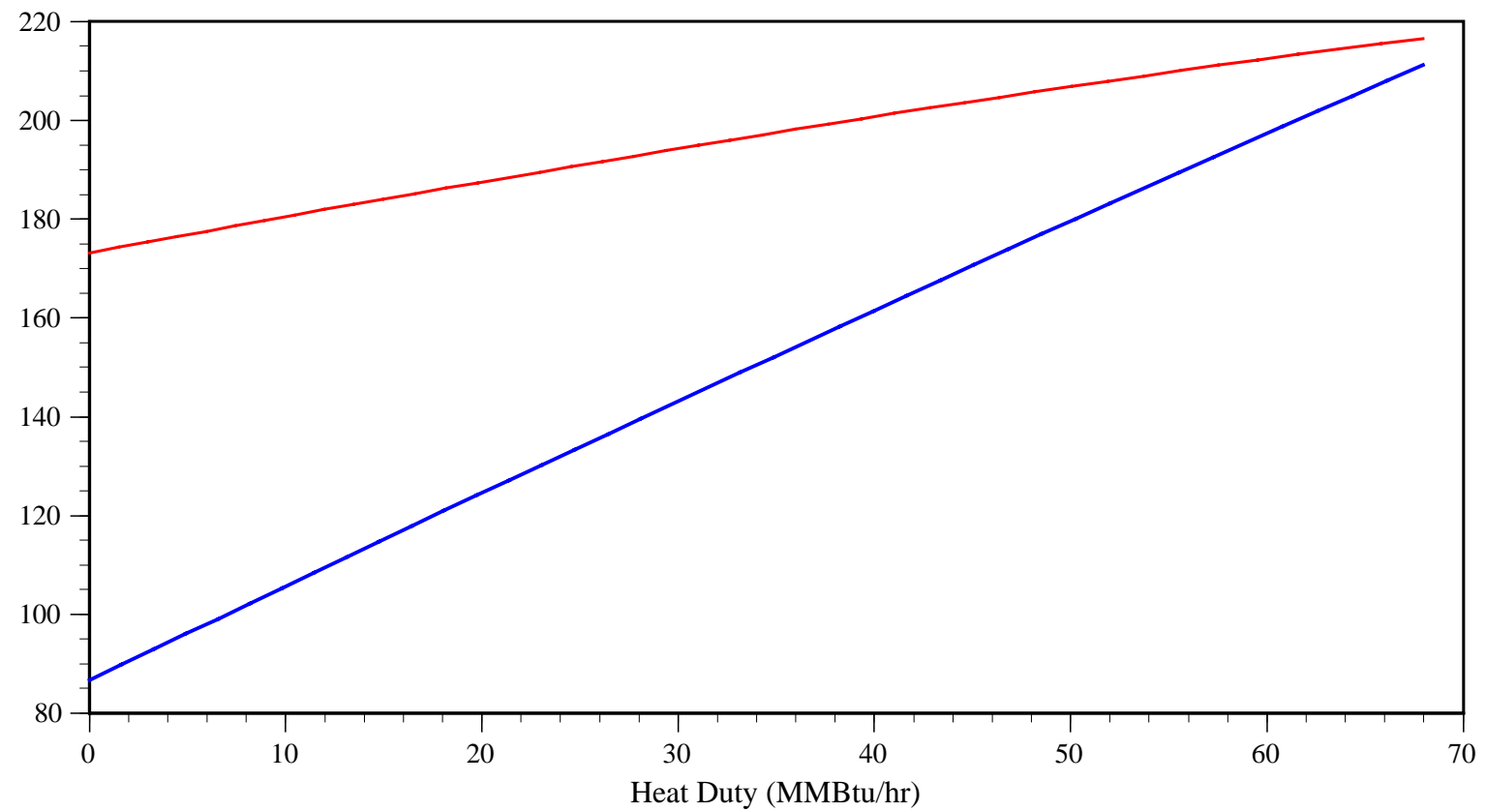
- Water-cooled shell & tube condensers, unless special water treatment (stainless steel to avoid rust on water side)
- Plate heat exchangers (stainless steel for strength and formability)
- Hybrid heat exchangers (stainless steel for strength and formability); shell is carbon steel
- No copper or copper alloys



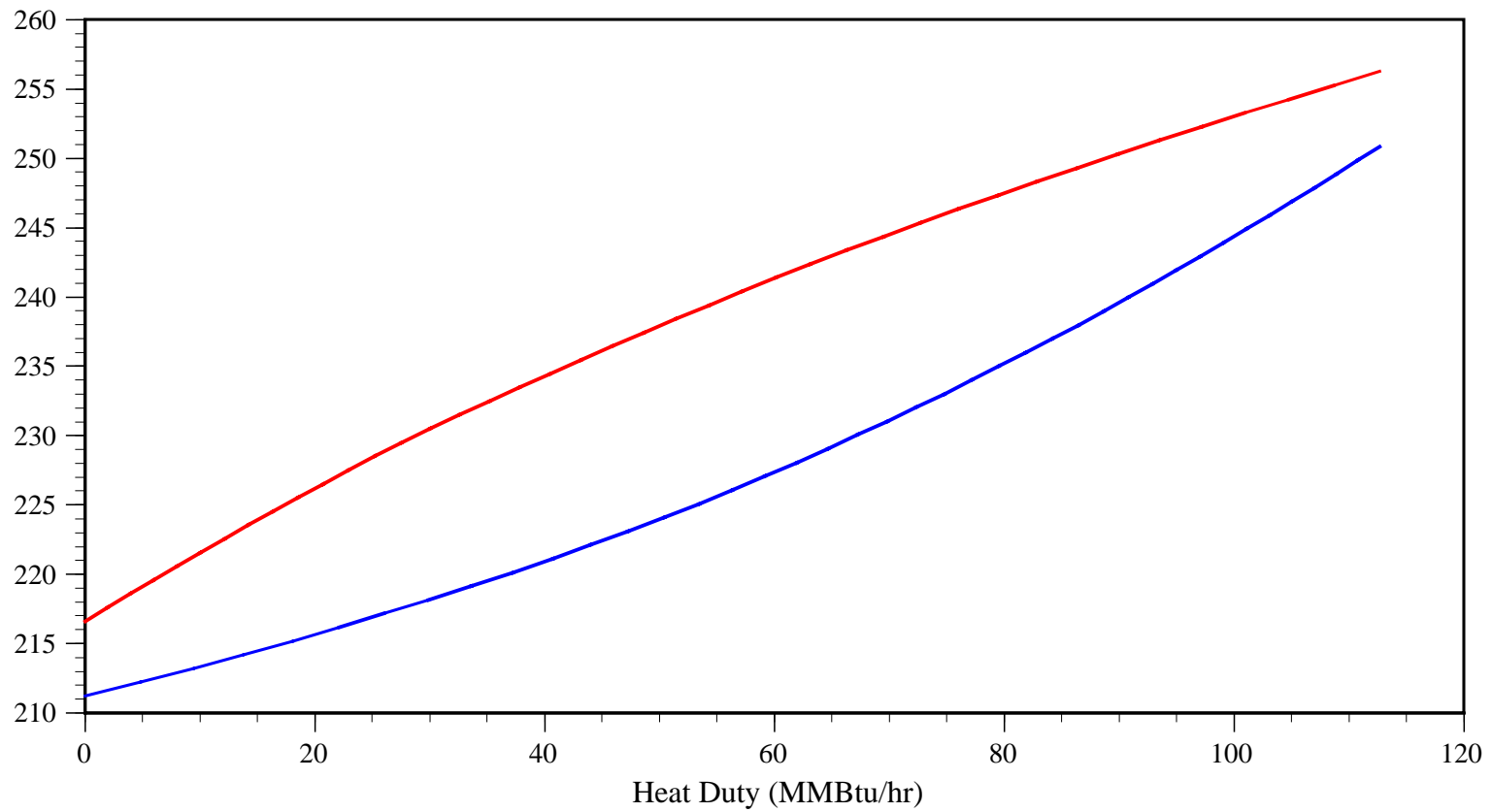
Hot Resource, Water Cooled: HE-1 (Condenser)



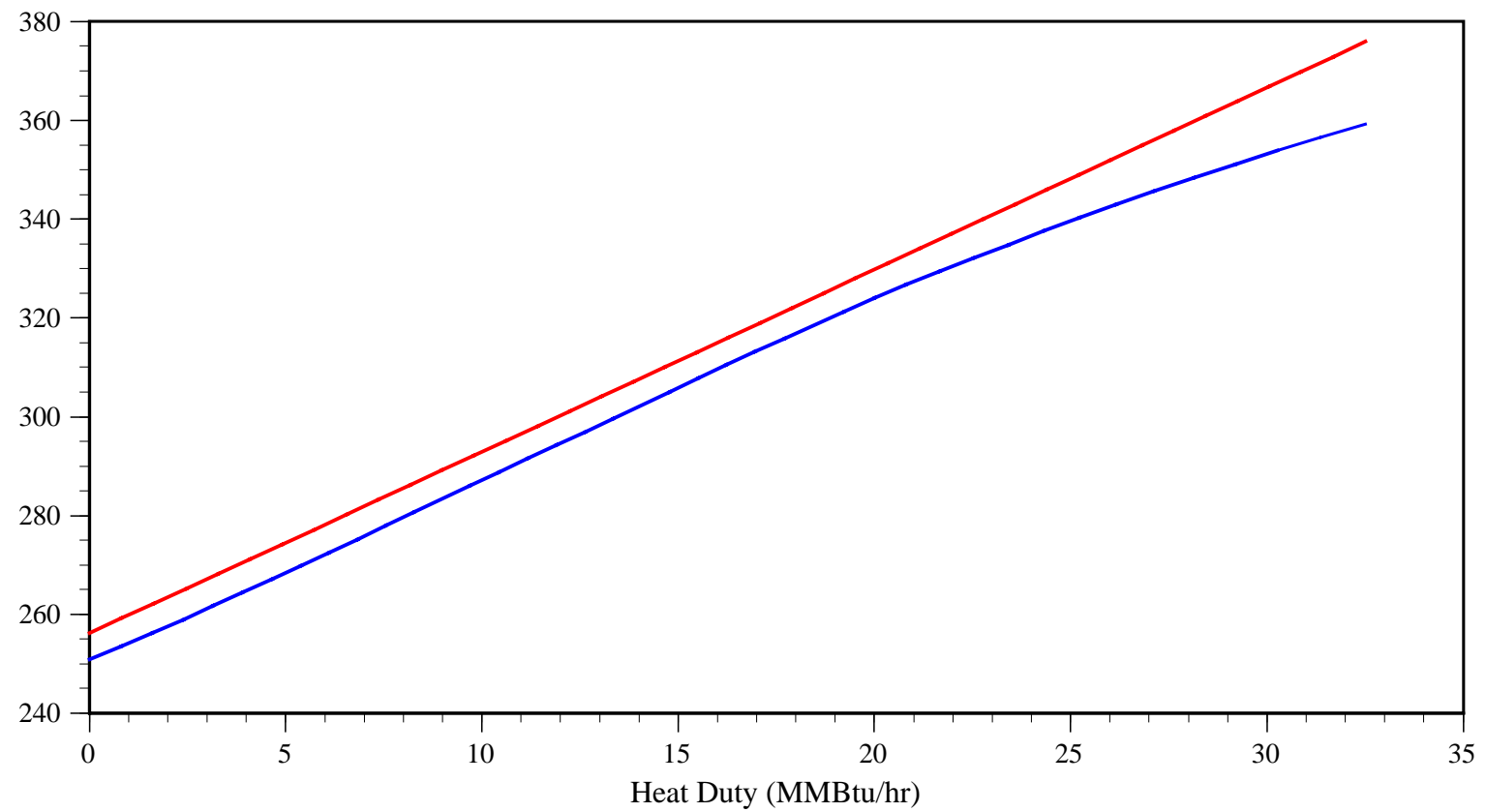
Hot Resource, Water Cooled: HE-2 (Low-Temperature Recuperator)



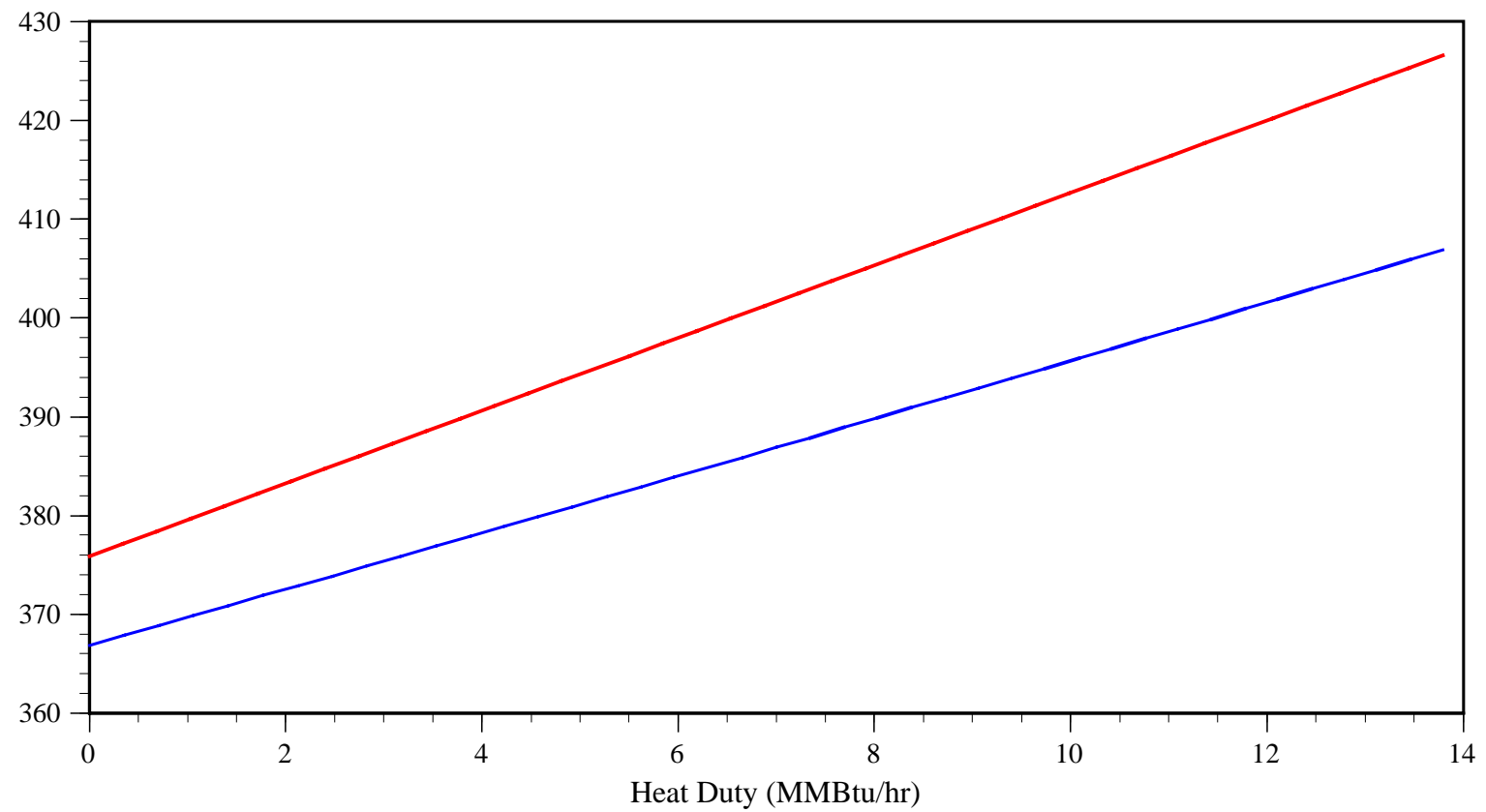
Hot Resource, Water Cooled: HE-3 (High-Temperature Recuperator)



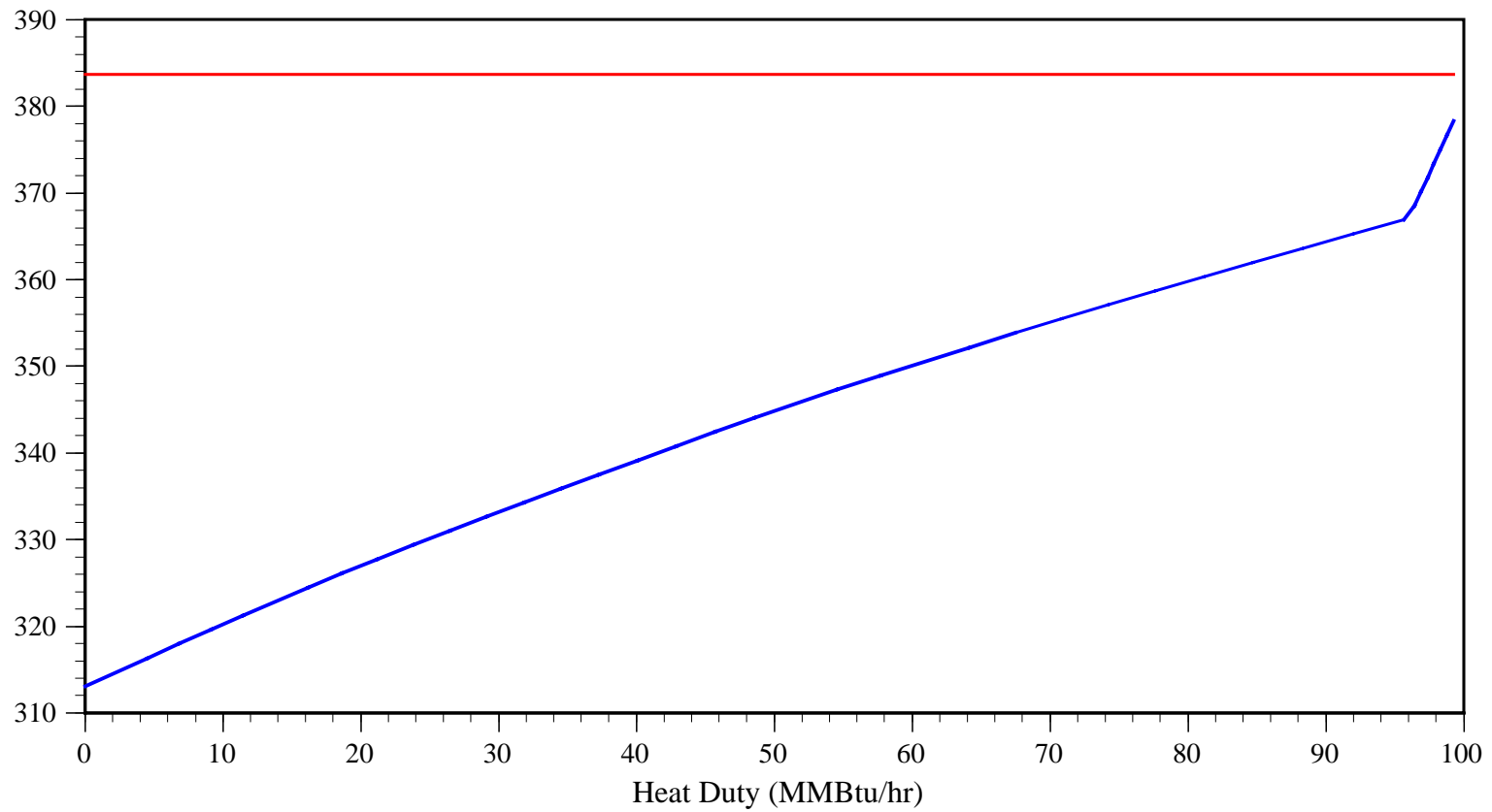
Hot Resource, Water Cooled: HE-4 (Evaporator)



Hot Resource, Water Cooled: HE-5 (Superheater)



Hot Resource, Water Cooled: HE-6 (High-Temperature Steam Condenser)



Hot Resource, Water Cooled: HE-7 (Low Temperature Steam Condenser)

